

Appln No. 10/037,414

Amdt date July 29, 2004

Reply to Office action of January 29, 2004

Amendments to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application:

Listing of Claims:

Please cancel claims 1, 2 and 9, and amend claims 3-7 and 10-14.
Please add new claims 19-57.

1. (Cancelled)
2. (Cancelled)
3. (Currently Amended) The apparatus of Claim ~~[[1]]~~ 19 where the photon source is a quartz halogen tungsten lamp or other suitable light sources.
4. (Currently Amended) The apparatus of Claim ~~[[1]]~~ 19 further comprising ~~[[where]]~~ reflectors ~~[[are used]]~~ to optically couple the photon source to the light pipe.
5. (Currently Amended) The apparatus of Claim ~~[[1]]~~ 19, where ~~[[the]]~~ power level to the photon source and ~~[[the]]~~ a welding time interval are controlled.
6. (Currently Amended) The apparatus of Claim ~~[[1]]~~ 19, where cooling means are employed to reduce ~~[[the]]~~ welding cycle time.

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7. (Currently Amended) The apparatus of Claim ~~[[1]]~~ 19, where the components to be welded are carried in a nest and the following sequence of automated steps occurs: the nested components move into the welding position, ~~[[a]]~~ the light pipe with the mask contacts the ~~[[transmissive layer]]~~ first component of the work piece, ~~[[a compression]]~~ the compressive force is applied to the work piece, the ~~[[radiation]]~~ photon source is activated for a prescribed interval, cooling means are activated when ~~[[required]]~~ light pipe overheats, after an appropriate delay period the compressive force is removed, the welded work piece is withdrawn from contact with the light pipe, and the work piece is removed from the nest.

8. (Withdrawn) An automation photon welding apparatus comprising:

- a mechanism to load and unload unwelded components onto a conveyor or belt-driven system;

- a system to pre-heat the components to be welded;

- a welding apparatus built within the principles introduced by the invention;

- a mechanism to align the components to the masked light pipe;

- an integrated control device to automatically and easily change parameters such as weld time exposure, force applied to components, belt speed, pre-heat temperature, and cooling if so desired by the operator; and

- a combination of pneumatic pistons and optical sensors to control, move, measure, and align components to be welded.

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9. (Cancelled) A photon welding method comprising:
- a photon source;
 - a light pipe coupled to the photon source at one end and a raised section at the other end that defines the weld location for photon delivery;
 - a work piece to be bonded that consists of a top layer of transparent plastic and a base layer of absorbing plastic;
 - a mask consisting of a reflective coating on the end of the light pipe on all surfaces not in contact with the work piece;
 - a means of applying a controlled, compressive force to the work piece during the weld and a short time thereafter;
 - a means of maintaining the alignment of the light pipe, top layer of the work piece, and base layer of the work piece during the bonding cycle.

10. (Currently Amended) A photon welding apparatus[[,]] for joining one component [[part]] that is highly photon absorbing to [[the other part]] another component that is highly photon transmissive, [[that comprises]] comprising:

- a non-coherent photon source which is held in place by a structural support which connects the non-coherent photon source [[system]] to [[the]] a base by means of a structural support; [[and further comprises]]

- a movable plate which is designed to move the components to [[the mask]] a masked end of [[the]] a light pipe optically coupled to the photon source and to apply pressure to

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the components to be welded where pressure is applied by at least one of the following: levers, cams, pistons, linear actuators, springs [[or]] and any other means that produce the same effect~~[[; and further comprises a means]]~~, wherein the light pipe is adapted to [[make the light source]] uniformly [[dispersed]] disperse light from the photon source over [[the open]] unmasked areas of the [[mask]] masked end of light pipe to [[initially simultaneously]] irradiate the highly photon absorbing component which in turn conducts heat to the [[transparent]] highly photon transmissive component when held under pressure; and [[further a]]

means to assist in [[the]] alignment of the components and the light pipe; [[and further a]]

means to cool the light pipe, [[masks]] the mask and the reflector; [[and further]]

a nest to align the [[parts]] components where the nest is connected to the movable plate; and [[further comprising]]

timing means which times [[the]] a radiation exposure, as well as the full cycle including post exposure hold and cooling.

11. (Currently Amended) An apparatus as in claim 10, further comprising [[a]] means to apply even pressure to the [[parts]] components where such means shall be selected from the group: set of springs, universal ball joint, floating pneumatic system, and floating hydraulic system.

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12. (Currently Amended) An apparatus as in claim 10, ~~[[which]] further [[comprises]]~~ comprising multiple nests connected to the movable plate and ~~[[further5 comprising]]~~ a different mask and a different non-coherent photon source for each ~~[[part]]~~ nest.

13. (Currently Amended) An apparatus as in claim 10, ~~[[except it comprises a]]~~ further comprising movable means ~~[[that is]]~~ connected to the light pipe ~~[[and moves]]~~ for moving it to contact the fixed base where the nest and the components are located.

14. (Currently Amended) An apparatus as claimed in 10, further comprising ~~[[that further comprises a]]~~ means to monitor temperature of one selected from the group of; light pipe, mask, components, and reflector.

15. (Withdrawn) A semi-automated photon welding apparatus that comprises a non-coherent photon source with a photon collection system such as a reflector; and further comprises a means to hold the photon sources fixed in place by a structural support, which connects the non-coherent photon source to the base by means of structural support; and further comprises a conveyor belt system to feed and load the components to be welded, which also contains a pallet with one or more nests; the conveyor moves the components into position, aligns them and lock the pallet, then one or more mechanical means such as a piston fitted with a universal joint and thus applies pressure

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to the components to be welded by bring them in contact with the mask and holding the components under pressure; and further comprises a means to make the light uniformly dispersed over at least the open area of the mask so that it simultaneously and uniformly heats up the highly absorptive component(s) first and which conducts the heat to the transparent component and heats it to melting at the interface only such that a strong weld is accomplished and these components are held under pressure by some mechanical means including at least one selected from the following group: piston, linear actuator, levers, cams or any other means to produce the same effect; and further comprises a means to cool the light pipe and/or mask and a means to cool the reflector of the non-coherent source; and further comprises a nest to hold and align at least two components where the lower component is highly absorbent of at least a major portion of the photons from the non-coherent source and the top component is highly transmissive of the photons; and further comprising a nest that is part of the pallet; and further comprises a timing means, which times the radiation exposure (lamp on time) and each phase of the full cycle including post exposure hold to assure a quality weld and cooling of the lense and/or light pipe.

16. (Withdrawn) An apparatus as claimed in claim 15 further comprising a means to apply even pressure to the components to be welded such means may be selected from the group: 1) set of springs, 2) universal ball joint, 3) Floating pneumatic and 4) floating hydraulic.

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17. (Withdrawn) An apparatus as claimed in claim 16 that further comprises multiple nests each aligned with a photon source and the nest are connected to one movable plate and further comprises multiple masks that work in unison such that parts are welded at the same time.

18. (Withdrawn) An apparatus as claimed in claim 15 that comprises a means to measure temperature at one or more of the following locations: 1) light pipe, 2) reflector, and 3) mask.

19. (New) A photon welding apparatus for welding a work piece comprising a first component of transparent or transmissive plastic and a second component of absorbing plastic, comprising;

a non-coherent photon source;

a light pipe optically coupled to the photon source at one end to receive photons from the photon source and adapted to deliver the photons to its other end that is configured with a mask to allow the photons to exit the other end through an unmasked area to strike the workpiece in forming a weld between the components, the mask being a reflective coating on areas of the other end of the light pipe configured not to contact with the work piece;

means for applying compressive force to the work piece during welding and a short time thereafter; and

means for maintaining alignment of the light pipe, the first component and the second component during welding.

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20. (New) An apparatus of claim 19, wherein the light pipe is comprised of silicon dioxide, glass or other suitable materials.

21. (New) An apparatus of claim 19, wherein exiting photons from the light pipe strike the first component before striking the second component.

22. (New) An apparatus of claim 19, wherein the first component is adapted to transmit striking photons.

23. (New) An apparatus of claim 19, wherein the second component is adapted to absorb striking photons.

24. (New) An apparatus of claim 19, wherein the second component is adapted to melt upon absorption of photons.

25. (New) An apparatus of claim 19, wherein the second component is adapted to transmit heat sufficient to melt the first component.

26. (New) An apparatus of claim 19, wherein the unmasked area defines a contact area between the other end of the light pipe and the workpiece.

27. (New) An apparatus of claim 26, wherein the weld is formed within the contact area.

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28. (New) A method for photon welding a work piece comprising a first component of transparent or transmissive plastic and a second component of absorbing plastic, comprising;

providing a non-coherent photon source;

providing a light pipe and coupling the photon source to one end of the light pipe adapted to deliver the photons to its other end that is configured with a mask to allow the photons to exit the other end of the light pipe through an unmasked area to strike the workpiece in forming a weld between the components, the mask being a reflective coating on the other end of the light pipe not configured for contact with the work piece;

applying a controlled, compressive force to the work piece during welding and a short time thereafter; and

maintaining alignment of the light pipe, the first component and the second component during welding.

29. (New) A method of claim 25, further comprising: preheating the work piece.

30. (New) A method of claim 29, wherein the work piece is preheated to about 50 C.

31. (New) A method of claim 29, wherein the work piece is preheated to about 110C.

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32. (New) A method of claim 25, wherein the compressive force ranges between about 7-10 pounds.

33. (New) A method of claim 25, wherein the components have a width ranging between about 25 to 30 mm and the compressive force is about 45 Newtons.

34. (New) A method of claim 25, wherein welding time is about 10 seconds and post-weld time is about 5 seconds.

35. (New) A photon welding apparatus for welding a work piece comprising a first component of transparent or transmissive plastic and a second component of absorbing plastic, comprising;

a non-coherent photon source;

a light pipe optically coupled to the photon source at one end to receive photons from the photon source and adapted to deliver the photons to its other end that is configured with a region in contact with the work piece, the other end having a mask to allow the photons to exit the other end of the light pipe through an unmasked area to strike the workpiece in forming a weld between the components, the mask being a reflective coating on remaining region of the other end of the light pipe not in contact with the work piece; and

wherein the weld is formed from photon absorption melting of the second component and convection or conductive melting of the first component.

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36. (New) An apparatus of Claim 35, wherein the second component is configured a cavity defined by a periphery and the weld is located along the periphery.

37. (New) An apparatus of Claim 36, wherein the periphery has a circular shape.

38. (New) An apparatus of Claim 36, wherein the periphery has a rectangular shape.

39. (New) An apparatus of Claim 36, wherein the periphery has a L-shaped recess or a butt joint.

40. (New) An apparatus of Claim 35, further comprising cooling means to cool the other end of the light pipe.

41. (New) An apparatus of Claim 35, further comprising a reflector to direct the photons from the photon source to the one end of the light pipe.

42. (New) An apparatus of Claim 35, further comprising cooling means to cool the reflector.

43. (New) An apparatus of Claim 35, further comprising a temperature sensor to monitor temperature of the other end of the light pipe and activate the cooling means.

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44. (New) An apparatus of claim 35, further comprising a temperature sensor to monitor temperature of the reflector and activate the cooling means.

45. (New) An apparatus of claim 35, wherein the photon source comprises a quartz halogen tungsten lamp.

46. (New) An apparatus of claim 45, wherein the lamp exhibits a spectra peaking in the infrared at about 1000 nm for filament temperatures of about 3000K.

47. (New) An apparatus of claim 35, wherein the mask comprises one of the following: gold, silver, aluminum and chrome.

48. (New) An apparatus of claim 35, wherein a weld time is about 10 seconds and a post-weld time is about 4 seconds.

49. (New) An apparatus of claim 40, wherein the cooling means comprise a heat dissipater or heat sink.

50. (New) An apparatus of claim 40, wherein the cooling means comprise a water cooled heat exchanger.

51. (New) An apparatus of claim 40, wherein the cooling means comprise heat pipes.

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52. (New) An apparatus of claim 40, wherein the cooling means comprise an annulus providing compressed air.

53. (New) An apparatus of claim 35, wherein the photon source is a quartz-halogen tungsten lamp with a power range between about 410 to 1000 watts.

54. (New) An apparatus of claim 35, wherein the light pipe comprises a thin laminated glass lense and the mask comprises embedded gold, silver or aluminum.

55. (New) An apparatus of claim 35, wherein the light pipe comprises a machined quartz lense and the mask comprises an aluminum coating.

56. (New) An apparatus of claim 35, wherein the light pipe has a diameter no greater than two inches

57. (New) A photon welding apparatus for welding a work piece comprising a first component of transparent or transmissive plastic and a second component of absorbing plastic, comprising;

a non-coherent photon source;

a light pipe optically coupled to the photon source at one end to receive photons from the photon source and adapted to deliver the photons to its other end that is configured with a region in contact with the work piece, the other end having a mask to allow the photons to exit the other end of the light

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pipe through an unmasked area to strike the workpiece in forming a weld between the components; and

wherein the weld is formed from photon absorption melting of the second component and convection or conductive melting of the first component.

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Amendments to the Drawings:

The attached sheets of drawings include changes to Figures 1a, 2a, 2b, 3, 4a, 4b, 5a-5d, 6a, 7a-7h, 8 and 9. These sheets, which include Figs. 1a, 1b, 2a, 2b, 3, 3a, 3b, 4a-4d, 5a-5h, 6a, 6b, 7a-7h, 8 and 9, replaces the original sheet including Figs. 1a, 1b, 2a, 2b, 3, 4a, 4b, 5a-5d, 6a, 6b, 7a-7h, 8 and 9.

Attachment: Replacement Sheets

Annotated Sheets Showing Changes